Not lean by default

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Chapter 1

Introduction

1.1 Lean manufacturing

Lean manufacturing has been widely adopted by manufacturers in an effort to improve quality, reduce throughput times, and reduce costs (Albliwi, Antony, Abdul Halim Lim, & van der Wiele, 2014). Lean manufacturing originated in a repetitive manufacturing environment (Hines, Holweg, & Rich, 2004), but was later adopted by manufacturers in non-repetitive manufacturing environments as well (Portioli Staudacher & Tantardini, 2012). Even outside manufacturing industries, the application of lean principles has become widespread. Hospitals (D'Andreamatteo, Ianni, Lega, & Sargiacomo, 2015), service providers (Piercy & Rich, 2009), and governmental institutions (Radnor & Walley, 2008), for example, have adopted lean principles. The widespread adoption of these principles suggests that they are beneficial. Nevertheless, most studies find that the adoption of lean principles often does not result in the expected benefits (see also Albliwi et al., 2014; Stentoft Arlbjørn & Vagn Freytag, 2013 for reviews of literature). As such, there is a need to study the relation between lean manufacturing and performance in more detail.

In order to study the relation between lean manufacturing and performance, a definition of lean manufacturing is needed. The problem is, however, that lean manufacturing does not have a clear, concise, or consistent definition (Bhamu, Sangwan, & Singh Sangwan, 2014; Stentoft Arlbjørn & Vagn Freytag, 2013). Lean manufacturing has, amongst others, been characterized as a concept, a philosophy, a set of principles, a set of practices, a set of bundles, or a collection of tools and techniques (Bhamu et al., 2014). More importantly, studies seem to disagree on the operationalization of the concept, the tenets of the philosophy, the principles to include, the practices to incorporate, whether or not these practices should be studied together or in isolation, and which tools and techniques are part of the lean toolkit (Stentoft Arlbjørn & Vagn Freytag, 2013). The lack of a consistent definition might explain why some studies report positive results, whereas others do not. In any case, the lack of a commonly agreed upon definition may explain why literature on lean manufacturing remains inconclusive with respect to whether or not lean manufacturing actually improves performance and, if so, what elements of lean manufacturing contribute most to improved performance.

In light of the absence of a shared definition, we need to rely on a different way to conceptualize lean manufacturing. A number of ways have been suggested. Shah, Chandrasekaran, and Linderman (2008), for example, suggest that it is helpful to distinguish between different levels of abstraction when it comes to lean manufacturing. Distinguishing between various levels of abstraction allows us to separate strategic and operational concerns, general principles and specific tools, long- and short-term interests, and general guidelines and specific goals. The classification suggested by Shah, Chandrasekaran & Linderman (2008) consists of three levels of abstraction, namely: (1) lean manufacturing as a management philosophy, (2) lean manufacturing as a set of manufacturing practices, and (3) lean manufacturing as a collection of specific tools and techniques. Similar classifications have been adopted by others for similar purposes (e.g. Dean & Bowen, 1994; Shah & Ward, 2007; Stentoft Arlbjørn & Vagn Freytag, 2013).

Table 1.1 provides an example of the classification. The example lists the principles and tools and techniques associated with the practice of pull production. Pull production practices are used in support of waste elimination efforts as lowering work-in-progress allows potential sources of waste to surface, be identified, and subsequently be eliminated (Hopp and Spearman, 2004). The manner in which the practice of pull production itself is implemented depends on the specific tools and techniques used in support of the practice. Manufactures combine different tools and techniques to create a unique implementation of the practice particularly suited to their needs. For instance, pull production systems with route-specific cards and overlapping work-in-progress restrictions have different properties than pull production systems with product-specific cards and non-overlapping work-in-progress restrictions. These properties make pull systems with route-specific cards and overlapping control loops better

Table 1.1. Lean manufacturing classification

Principles	Practices	Tools and techniques
Eliminate waste	Setup time reduction	Product-specific cards
Continuously improve	**Pull production**	Product-anonymous cards
Empower employees	Process management	**Route-specific cards**
…	Quality data analysis	Separate work-in-progress restrictions
	Management leadership	Shared work-in-progress restrictions
	People management	**Overlapping work-in-progress restrictions**
	Just-in-time deliveries from suppliers	…
	Supplier quality management	
	…	
general	↔	specific
context independent	↔	context-dependent
informal	↔	formal
long-term	↔	short-term
strategic	↔	operational

[1]Examples of principles, practices, and their associated tools and techniques are shown in **bold**.

suited for make-to-order manufacturing environments than pull systems with product-specific cards and non-overlapping work-in-progress restrictions (Riezebos, 2010; Ziengs, Riezebos, & Germs, 2012). The example illustrates the need to consider lean manufacturing on levels of abstraction.

Lean manufacturing, as a management philosophy, provides manufacturers with a set of general principles or guidelines (Bhasin & Burcher, 2006). These principles have their roots in just-in-time and quality management approaches and direct manufacturers to eliminate waste, continuously improve, and empower employees in order to provide value for their customers (Dal Pont, Furlan, & Vinelli, 2008; Stentoft Arlbjørn & Vagn Freytag, 2013). Although these general principles are useful when establishing a long-term operations strategy, they only serve as a guiding principle when trying to implement such a strategy. Therefore, it is not surprising, that manufacturers go about implementing similar strategies in markedly different ways (Bhasin & Burcher, 2006). Different manufacturers emphasize different tenets of the philosophy, implement different practices as part of their strategy, and train employees in the use of particular tools and techniques depending on their specific needs. Nevertheless, the core tenets of the philosophy are remarkably consistent across studies. As such, viewing lean manufacturing as a philosophy helps us to understand what lean adherents attempt to achieve, but not how they will achieve their goals.

Lean manufacturing, as a set of manufacturing practices, provides manufacturers with the means to achieve the general goals outlined by the philosophy. That is, lean manufacturing practices are used to implement the lean philosophy. Each principle is implemented through a set of manufacturing practices, such as process management, pull production, or small group problem solving (Furlan, Vinelli, & Dal Pont, 2011). These practices are general enough to be comparable across organizations, yet specific enough to explore to what degree these constituent elements of lean manufacturing relate to performance (e.g. Dean & Bowen, 1994). As such, and perhaps not surprisingly, a large number of empirical studies investigate the relation between these lean manufacturing practices and performance in an effort to determine how they jointly or separately result in performance improvement (see Mackelprang & Nair, 2010; and Nair, 2006 for meta-analyses).

Lean manufacturing, as a collection of tools and techniques, provides manufacturers with the means to support the implementation and use of lean manufacturing practices. These tools and techniques are often highly specific and serve an equally specific purpose. For example, to implement process management practices, such as statistical process control, manufacturers use different types of control charts (see Oakland, 2008 for an overview of different control charts). As another example, manufacturers can use different types of cards and different implementations of work-in-progress restrictions to create a unique implementation of the lean manufacturing practice of pull production (see Thürer, Stevenson, & Protzman, 2016a for an overview of different pull systems).

In short, to understand how lean manufacturing results in improved performance, it is important to consider not only the general principles involved but also the manufacturing practices used to implement these principles and the associated tools and techniques used in support of these practices. As such, in line with Shah and Ward (2003), lean manufacturing will be characterized as managerial philosophy implemented through a set of manufacturing practices supported by a large number of specific tools and techniques with their roots in quality management, just-in-time manufacturing, and human resource management. To provide recommendations for lean implementations it is particularly important to study lean manufacturing practices and their associated tools and techniques. The general principles that are shared across lean implementations by themselves provide little guidance with respect to the implementation of lean, whereas insight into how to select and combine practices or even tools and techniques is of great practical value. Consequently, in this dissertation, the focus is on the second and third level of the abstraction outlined above.

1.2 Lean manufacturing practices

As stated, lean manufacturing is often considered as a set of manufacturing practices (e.g. Shah & Ward, 2007; Tortorella, Miorando, & Marodin, 2017). Examples of lean manufacturing practices are process management, pull production, and small group problem-solving. Numerous papers, published in the last thirty years, have been dedicated to studying how these lean manufacturing practices affect performance (see Mackelprang & Nair, 2010; Nair, 2006 for meta-analyses). Implementing selected lean manufacturing practices allows manufacturers to develop their own approach to lean.

The first studies published in the 1990s conceptualized lean manufacturing as a set of separate or interrelated practices (e.g. Cua, McKone, & Schroeder, 2001; Flynn, 1994; Flynn, Sakakibara, & Schroeder, 1995). These studies were mostly dedicated to determining how subsets of lean manufacturing practices, such as quality management practices (e.g. Flynn, 1994), just-in-time manufacturing practices (e.g. Chang & Lee, 1995), or a combination of both (Cua et al., 2001; Flynn, Sakakibara, et al., 1995) relate to performance. Moreover, these studies not only considered the practice performance relationship, but also the relationships amongst lean manufacturing practices themselves. These studies explored whether certain lean manufacturing practices directly or indirectly, by enabling the effective use of other practices, relate to performance (e.g. Flynn, Sakakibara, et al., 1995). Subsequent studies also addressed the circumstances under which the practice performance relationship was strongest by exploring the role of possible moderators (e.g. White, Pearson, & Wilson, 1999).

These studies attempted to aid manufactures with the selection of lean manufacturing practices and reported mostly positive relations between lean manufacturing practices and performance (see also Mackelprang & Nair, 2010; Nair, 2006 for meta-analyses). However, the strength of the relation between lean manufacturing practices and performance reported varied considerably across studies which suggest that context, as well as other practices, play an important role when it comes to improved performance. In addition, most studies reported positive relations amongst lean manufacturing practices as well which suggests that these practices are mutually reinforcing (e.g. Cua et al., 2001; Flynn, Sakakibara, et al., 1995; Flynn, Schroeder, & Sakakibara, 1994). However, the strength of these relations reported in different studies also varied considerably. Furthermore, different studies included different practices thereby making it difficult to assess the performance implications of lean manufacturing as a whole. As such, it remains difficult to conclusively state which practices are mutually reinforcing and, if so, to what degree and under which circumstances they are. Unfortunately, only a limited number of attempts have been made to explain the differences observed in these studies.

Subsequent studies started to conceptualize lean manufacturing not as a set of interrelated manufacturing practices, but rather as a set of interrelated bundles of practices (Bortolotti, Danese, Flynn, & Romano, 2015; Dal Pont et al., 2008; Shah & Ward, 2003). Conceptualizing lean manufacturing as a set of interrelated bundles acknowledges that lean practices are often not implemented in isolation and that practices within these lean bundles are likely to affect performance in similar ways. That is, studies that considered lean bundles recognized the mutually reinforcing character of lean manufacturing practices within specific bundles. Moreover, these studies also act on the observation that it is becoming difficult to (empirically) distinguish between separate lean manufacturing practices which suggests that lean manufacturing implementations have become increasingly integrated. In fact, even more recently, studies have started to consider lean manufacturing as a whole, rather than constituent bundles, or practices (e.g. Khanchanapong et al., 2014). These developments suggest that it has become more difficult to distinguish between separate lean bundles or practices. A possible explanation might be that lean implementations have become unique due to path dependencies associated with the implementation and refinement of specific practices over time (Netland, 2016). That is, past choices of manufacturers with respect to the implementation and refinement of practices have determined, at least to a degree, what practices can or will be implemented and how they will be implemented. These manufactures have therefore implemented similar practices in markedly different ways making it more difficult to distinguish between practices or even bundles of practices using the same empirical methods.

The most commonly identified bundles are the just-in-time, quality management, and human resource management bundles. According to Dal Pont et al. (2008), the quality management bundle consists of practices such as process management, product design and management, and quality data analysis. The just-in-time bundle consists of practices such as setup time reduction, lot size reduction, schedule adherence, and group technology. The human resource management bundle consists of practices related to small group problem solving, training, involvement, and empowerment.

The studies which consider lean manufacturing as a set of practices and those which consider lean manufacturing as a set of bundles address similar questions. These studies consider what lean manufacturing bundles to implement, whether other lean manufacturing bundles are necessary for successful implementation, and under what circumstances implementation is most likely to succeed. Similar as before, the results are inconclusive. Most studies report positive relations between bundles of lean manufacturing practices, but the strength of the relation between lean bundles and performance varies considerably across studies. Moreover, different studies include different practices in similar bundles thereby making it difficult to compare the performance implications of these bundles across studies. Furthermore, some studies consider direct effects of bundles (e.g. Shah and Ward, 2003) whereas others also consider indirect effects (e.g. Dal Pont et al. 2008; Bortolloti et al. 2015) which suggest that the role these bundles play in realizing improved performance is not entirely understood.

In short, despite the wealth of empirical literature on lean manufacturing, a number of important issues remain unresolved. First, the level of abstraction varies across studies. Studies consider lean manufacturing as a set of interrelated practices, a set of interrelated bundles of manufacturing practices, or lean as a whole which makes the comparison across studies difficult. Second, lean manufacturing practices or bundles are often not well defined. Definitions of lean manufacturing practices vary across studies which, again, makes comparison across studies difficult and sheds doubt on the conceptual integrity of the measurement instruments used. Notable exceptions notwithstanding, the choice which practices or bundles to include often appears pragmatic rather than informed by theory. Third, studies often fail to consider alternative models and resort to presenting the model that fits best. There is no consensus as to whether practices or bundles directly or indirectly affect performance. Model comparison, especially when these models are derived from competing theoretical perspectives, aids in the development of theory on lean manufacturing. Nevertheless, competing perspectives are rarely evaluated. As such, it becomes difficult to conclusively state, based on prior literature, whether certain lean manufacturing practices indeed affect performance positively and to what degree. Similarly, it is difficult to assess whether the successful implementation of certain lean manufacturing practices depends on the presence of other lean manufacturing practices and, if so, what the sequence of implementation should be.

These unresolved issues give rise to a number of problems. First, these issues make it difficult to build on prior literature to develop a comprehensive theory on lean manufacturing. The different levels of abstraction used, the inconsistent use of definitions and lack of comparison hinder model building, testing, and refinement. Second, these unresolved issues also make it difficult for practitioners to derive guidelines for the implementation of lean manufacturing practices from these studies. As such there is a need to synthesize the current literature base.

The previous discussion leads us to formulate the following general research objective which highlights the need to study lean at the second level of abstraction outlined previously. The **first objective** is to better understand how lean manufacturing practices jointly affect performance.

1.3 Lean manufacturing practices and their design

The first research objective addresses the relationship between lean manufacturing practices and performance. As such, the first research objective is expressed at the second level of abstraction outlined previously. However, to truly understand how lean manufacturing practices affect performance, it is important to consider the third level of abstraction as well. That is, the design of these lean manufacturing practices should be taken into account by looking at the associated tools and techniques used in support of the lean manufacturing practices. Considering lean manufacturing as a set of interrelated practices only aids us in understanding how constituent elements of lean manufacturing affect performance. However, considering lean manufacturing practices on the practice level only offers limited insight into why these practices affect performance as these practices can be implemented in various ways. In other words, studying lean manufacturing practices on the level of the practices does not shed light on the mechanisms by which these practices affect performance.

The design of lean manufacturing practices is often tailored to address specific needs even though these designs share a similar intent.

Here, the design of lean manufacturing practices refers to the selection of tools and techniques and the way in which they are used in support of the practices themselves. Consider, for instance, the lean manufacturing practice of pull production. Pull production is of particular interest because pull production can be implemented in markedly different ways (see Thürer, Stevenson, & Protzman, 2016a for an overview of different pull production systems). KANBAN (Sugimori, Kusunoki, & Cho, 1977), CONWIP (Spearman, Woodruff, & Hopp, 1990), and POLCA (Suri, 1998) all provide different ways to implement pull production. Each of these pull production systems uses different types of cards (e.g. product-specific, product-anonymous, and route-specific) and relies on different types of work-in-progress restrictions (e.g. separate, shared, or overlapping). The design of a pull production system can be tailored to match the specific circumstances manufacturers find themselves in by, for instance, selecting and implementing different types of cards and work-in-progress restrictions. To understand how to tailor lean manufacturing practices such as pull production, a thorough understanding of the mechanisms by which these lean manufacturing practices affect performance is required. Furthermore, a thorough understanding of the circumstances under which these mechanisms drive performance is also necessary. This sentiment is not new, others have also argued that it is important to move away from approaches that consider lean manufacturing as a set of practices to approaches which take the actual design and use of these practices on the shop floor into account (Hasle, Bojesen, Jensen, & Bramming, 2012).

The previous discussion leads us to formulate the following general research objective and highlights the importance of studying lean manufacturing practices at the second and third level of abstraction outlines previously. **The second objective** is to better understand how the design of lean manufacturing practices affects performance by studying the underlying mechanisms that drive performance.

1.4 Outline

The above discussion led us to formulate the two general research objectives outlined above: (1) to better understand how lean manufacturing practices jointly affect performance and (2) to better understand how the design of lean manufacturing practices affects performance by looking at the underlying mechanisms that drive performance. Each research objective is addressed in one of the following chapters. The chapters address a specific problem within the confines of the stated research objectives.

In chapter 2, we address the first research objective. To explore the interrelatedness of lean manufacturing practices, we look at a subset of lean manufacturing practices, namely core and infrastructural quality management practices. In the chapter, we use meta-analysis and structural equation modeling techniques to address the role that core and infrastructural quality management practices play when it comes to realizing improved performance. As such, in the second chapter, we address how these practices jointly affect performance. In chapter 2, we, therefore, consider the second level of the classification, namely lean manufacturing practices.

In chapter 3, we address the second research objective. To explore how the design of lean manufacturing practices affects performance, we look at the design of pull production systems. In the chapter, we use discrete-event simulation to address how the placement of work-in-progress restrictions affects the effective workload balancing capability of a unit-based pull production system. As such, in the third chapter, we address both the design and the underlying mechanism, namely workload balancing, that drives performance. In chapter 3, we, therefore, consider both the second and the third level of the classification.

In chapter 4, we also address the second research objective. To explore how the design of lean manufacturing practices affects performance, we, again, take the design of pull production systems as an example. In chapter 4, however, we use a controlled experiment to address how work-in-progress restrictions affect performance by influencing the behavior of individuals on the shop floor. Two mechanisms which direct the behavior of individuals on the shop floor are considered. As such, in the fourth chapter, we address both the design and the underlying mechanisms that drive performance. In the chapter, we, therefore, consider the third level of the classification.

In chapter 5, we address the contribution of each study to the associated research objective. In addition, we provide suggestions to explore each research objective further. In the next section, we provide an extended overview of each chapter.

1.4.1 Chapter 2 - The Distinctive Roles of Core and Infrastructural Quality Management Practices: A Meta-Analytical Structural Equation Modeling study

In chapter two, we explore the relationship between a subset of lean manufacturing practices and performance and address the first research objective. More specifically, we address the relationship between quality management practices and performance. The relation between quality management practices and performance is addressed because a considerable amount of empirical studies, dating back to the seminal work by Saraph, Benson, & Schroeder (1989), have reported on this relationship with various results. In addition, only a limited number of studies relate quality management practices to just-time time and associated human resource management practice thereby limiting the feasibility of including practices from other lean bundles in a single study.

Quality management practices are often divided into two categories, namely core and infrastructural quality management practices. Process Management, Product Design and Management, and Quality Data Analysis are examples of core quality management practices. The core quality management practices closely resemble the practices within the quality management lean bundle (Dal Pont et al., 2008; Shah & Ward, 2003). People management, Management

Leadership, Supplier Quality Management, and Customer Focus are infrastructural practices. The infrastructural quality management practices closely resemble practices included in other lean bundles such as the human resource management bundle (Dal Pont et al., 2008), the supply chain management bundle (Tortorella et al., 2017) or the fitness bundle (Bortolotti, Boscari, & Danese, 2015).

The role of infrastructural quality management practices, in particular, has been, and still is, the topic of considerable debate. Proponents of an indirect view argue that infrastructural quality management practices indirectly affect performance by providing support for core quality management practices and that infrastructural quality management practices need to be in place in order for core quality management practices to be effective. Proponents of a direct view argue that infrastructural practices directly affect performance and, therefore, quality management practices can be implemented in isolation. Both perspectives assume that core and infrastructural quality management practices are distinct which in itself is contested by a third perspective of which adherents suggest that such a distinction is not possible. These perspectives have been implicitly and explicitly used in previous studies and each has gathered considerable empirical support. Nevertheless, each perspective provides different suggestions with respect to the implementation of these practices. As such, it is necessary to settle this debate.

To evaluate these perspectives, we combine meta-analysis and structural equation modeling. First, we use meta-analysis to synthesize the empirical evidence documented in more than sixty studies. Second, we use the meta-analytically derived correlation matrix as an input for structural equation modeling. Confirmatory factor analysis allows us to evaluate whether core and infrastructural quality management practices are distinct (two-factor model) or indistinct (single-factor model). Structural equation modeling allows us to assess the relationship between quality management practices and performance.

The results of the meta-analysis show that core and infrastructural quality management practices are positively related to each other and performance. However, these relationships are subject to considerable heterogeneity which suggests moderators are at play. The results of the confirmatory factor analysis supports a single-factor model which suggests that it is difficult to distinguish between core and infrastructural quality management practices. The results of the structural equation model, in turn, suggest that quality management practices positively affect quality, operational and business performance. The results of the study further the debate on the role of infrastructural and core quality management practices and suggests that a universal yet customized approach to quality management is warranted.

1.4.2 Chapter 3 – The Placement of Effective Work-In-Progress Restrictions in Route-Specific Unit-Based Pull Production Systems: A Discrete-Event Simulation Study

In chapter 3, we explore the relation between production planning and control system design and performance and thereby address the second research objective. More specifically, we evaluate the workload balancing capability of unit-based pull production systems. Unit-based pull production systems regulate the release and dispatching of work by restricting the number of orders on the shop floor. Unit-based pull production systems are often used by manufacturers in an attempt to achieve shorter and more reliable throughput times.

To achieve short and reliable throughput times, manufacturers make use of the workload balancing capability of pull production systems, especially when confronted with routing variability. The workload balancing capability of a unit-based pull production system depends on its structure and configuration. The structure refers the number, size, and placement of work-in-progress restrictions. The configuration refers to the extent or the degree of the work-in-progress restrictions. In this study, we explore to what degree the effective workload balancing capability of a unit-based pull production system depends on the placement of work-in-progress restrictions on the shop floor.

Discrete-event simulation was used to explore the relation between the placement of work-in-progress restrictions and the effective workload balancing capability of a unit-based pull production system. Discrete-event simulation is suitable because it allows us not only to study the placement of work-in-progress restrictions, but also how the placement of these restrictions is affected by circumstances manufacturers find themselves as characterized by various levels of interarrival variability, processing time variability, utilization, and batch size. The structure of POLCA, a unit-based pull production system, was used because the multiple overlapping work-in-progress restrictions allowed us to consider the placement of work-in-progress restrictions whereas other structures would not.

The results of the simulation suggest that the placement of work-in-progress restrictions influences the effective workload balancing capability of the unit-based pull production system. Workload balancing on the shop floor is shown to be more effective than balancing at the moment of release especially for shorter routings. Workload balancing at the moment of release becomes more important once the routing becomes longer. The study underpins the importance of considering the design of the lean manufacturing practice, rather than whether or not the practice itself has been implemented.

1.4.3 Chapter 4 – Motivational Mechanisms in Work-In-Progress Restricted Production Systems: An Experimental Study

In chapter 4, we explore the relationship between coordination losses and motivation gains in work-in-progress restricted production systems and thereby address the second research objective. More specifically, we explore how pull production system design influences both coordination losses as well as motivation losses and gains. Pull production systems restrict work-in-progress on the shop floor which results in lower work-in-progress levels and shorter shop floor throughput times. However, low work-in-progress levels also result in an increase in idle time, or coordination loss, by creating interdependencies between resources on the shop floor. Unsurprisingly, most pull production systems are therefore designed to reduce work-in-progress to a degree which does not increase the interdependencies between shop floor resources.

A number of authors have argued that the negative consequences of increased interdependencies are overstated in production systems where workers are the primary determinant of processing times and suggest that the interdependencies should be exploited, rather than avoided. In work-in-progress restricted production systems, individuals adjust their effort in response to changes to the state of the system. Individuals are motivated to prevent idle time. That is, individuals decrease their effort if they themselves are likely to become idle and increase their effort when they are likely to cause others to become idle. Although the speed up (motivation gains) and slow down effects (motivation losses) that occur in work-in-progress restricted production systems have been demonstrated, the mechanisms that drive motivation gains in work-in-progress restricted systems and the subsequent consequences for production system design and performance are less well understood.

In this study, we consider two mechanisms which motivate individuals to adjust their effort in work-in-progress restricted production systems, namely social comparison and social indispensability. To evaluate the social comparison and social indispensability explanations, we conducted a controlled experiment.

The results provide evidence in support of both social comparison and social indispensability explanations. Furthermore, the results suggest that sequential interdependencies can be determinantal. In the presence of sequential interdependencies, social comparison and indispensability mechanisms seemingly mitigate the detrimental effects associated with these sequential interdependencies. The results also suggest that in the absence of the sequential interdependencies, social comparison results in improved performance. The study underpins the importance of considering the design of the lean manufacturing practices, rather than whether or not the the practice has been implemented.

1.4.4 Chapter 5 – Conclusion and Discussion

Chapter 2, 3, and 4 each report on a study which addresses one of the two research objectives. The first study addresses how lean manufacturing practices jointly affect performance. The second and third studies address how the design of lean practices affects performance. Each study relies on a different research approach to explore a specific question related to lean manufacturing practices, their design, and the underlying mechanisms that drive performance. In chapter five, we address the contribution of each study in relation to the general research objectives introduced in this chapter. In addition, we provide suggestion to explore each of these research objectives further.